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Assessing the distribution of social-ecological resilience and risk: Ireland as a case study of the uneven impact of famine

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Keywords: resilience, cluster analysis, Ireland, famine, entitlement, regime

Abstract

Explanations for the causes of famine and food insecurity often reside at a high level of aggregation or abstraction. Popular models within famine studies have often emphasised the role of prime movers such as population stress, or the political-economic structure of access channels, as key determinants of food security. Explanation typically resides at the macro level, obscuring the presence of substantial within-country differences in the manner in which such stressors operate. This study offers an alternative approach to analysing the uneven nature of food security, drawing on the Great Irish famine of 1845-1852. Ireland is often viewed as a classical case of Malthusian stress, whereby population outstripped food supply under a pre-famine demographic regime of expanded fertility. Many have also pointed to Ireland's integration with capitalist markets through its colonial relationship with the British state, and country-wide system of landlordism, as key determinants of local agricultural activity. Such models are misguided, ignoring both substantial complexities in regional demography, and the continuity of non-capitalistic, communal modes of land management long into the nineteenth century. Drawing on resilience ecology and complexity theory, this paper subjects a set of aggregate data on pre-famine Ireland to an optimisation clustering procedure, in order to discern the potential presence of distinctive social-ecological regimes. Based on measures of demography, social structure, geography, and land tenure, this typology reveals substantial internal variation in regional social-ecological structure, and vastly differing levels of distress during the peak famine months. This exercise calls into question the validity of accounts which emphasise uniformity of structure, by revealing a variety of regional regimes, which profoundly mediated local conditions of food security. Future research should therefore consider the potential presence of internal variations in resilience and risk exposure, rather than seeking to characterise cases based on singular macro-dynamics and stressors alone.

1. Introduction: resource security, social structure, and the uneven impact of famine

Human suffering throughout periods of famine is rarely due to lack of food alone. Causes of food insecurity arise not only from inadequacies in food availability and supply channels, but from numerous social factors, such as regional and international trade relations, demographic and agrarian structures, land tenures, political systems and conflicts, and domestic market conditions. Within countries, the experience of famine is rarely uniform, and its uneven geographical impact calls into question the validity of food security analyses based on dominant variables alone. Famine research has long criticised models of food security based

on ‘de-contextualised Malthusianism’, which depict famines as a consequence of population growth outstripping food production (Hughes, 2000). In response, a number of frameworks have emerged in recent decades which have examined resource security, not as a product of destabilising variables such as population growth, but as a result of political-economic failures, or patterns of cumulative risk exposure specific to the nature of local ecosystems.

Within the social sciences, Amartya Sen’s entitlements framework offers one of the most potent challenges to Malthusianism in studies of food security (1976, 1980, 1981). Sen’s approach focuses not only on direct food availability, but also on the various productive, and political-economic channels (entitlements), through which populations may secure food. Insecurity and famine thus result from a cumulative collapse of entitlements, where food supply is disrupted by an inability to grow subsistence food (direct entitlements), an inability to exchange labour or property on the market (indirect entitlements), or an absence of adequate systems of public relief and social security (transfer entitlements). In combination, the presence of functioning entitlement channels lowers the probability of a population’s exposure to resource scarcity, and variations in local famine severity may be explained in terms of their presence or absence.

Environmental sociology has been slow to respond to the project of integrating both ecological and social variables in human-coupled ecosystems analysis however, focusing instead on the realms of culture and discourse. Much debate within sociology on natural-social integration has centred on delineating *the social* as a distinct object of scientific investigation; as a result, much research has focused specifically on the roles of culture and knowledge. Some have critically analysed the centrality of scientific knowledge in public discourse, whilst others working within the rubric of Actor-Network Theory have focused on developing alternative, ‘co-constructivist’ theoretical models of the relationship between nature and society (Dickens, 1996; Latour, 2004, 2005; Murdoch, 2001; Yearley, 2005). Although these approaches offer valuable insight into the public framing of ecological issues, the cultural underpinnings of land-use patterns, and the social-systemic foundations of environmental impact, they offer less to directly inform empirical analyses of the distribution of food security.

More recently, researchers drawing on the interdisciplinary framework of resilience ecology have reasserted the importance of social structure (Adger, 2000; Holling, 2001; Janssen, Anderies and Ostrom, 2007; Walker et al., 2006). These authors have suggested focusing on the social-ecological characteristics of food production systems themselves, in order to explain the causes of resource insecurity in specific contexts. (Abel, Cumming and Andrews, 2006; Berkes, Colding and Folke, 2003; Cumming et al., 2005; Fraser 2006, 2007; van Apeldoorn et al., 2011). Contrasted with *engineering* resilience as a measure of a systems’ return to its ‘base state’ following disturbance, *ecological* resilience assesses the amount of disturbance a system may undergo before transition to an alternate state is induced (Gunderson, 2003). The probability of a particular system crossing this threshold is determined by its *adaptive capacity*, or its ability to appropriately respond to feedback (Berkes, Colding and Folke, 2003; Fabricius and Cundill, 2011; Matthews and Sydneysmith, 2011). The utility of an ecological resilience approach, as opposed to a ‘stability’ or engineering resilience approach, rests in its use of the concepts of *regime* and *identity*, as opposed to equilibrium and structure. A *regime* may be conceptualised as a ‘...locally stable or self-reinforcing set of conditions...the dominant set of drivers and feedbacks that lead to system behaviour’ (Cumming, 2011: 14). Specific social-ecological systems may be

conceptualised as particular assemblages of institutions and structures, constituting a particular *identity* (ibid).

Ireland is a country which offers an ideal testing ground for the analytical potential of a resilience approach. The Great Irish Famine of 1845-1852 has been described as the ‘...last great subsistence crisis of the Western world’ (Kennedy and Clarkson, 1993: 158), with mortality estimates ranging from 800,000 (Cousens, 1960), to 1,000,000-1,500,000 (Mokyr, 1980), or 9.8% - 18.3% of total population. As with other cases of famine, it has proven difficult to ascertain the proportions of population decline attributable to starvation, death by disease, or emigration respectively, although Boyle and Ó’ Gráda estimate a population loss due to excess death of 981,000 throughout the famine period (1986: 555). To date, little attention has been given to the social factors underpinning spatial variations in the experience of famine, much less the manner in which local conditions mediated the experience of distress throughout this period. Much existing work has placed the blame for the Great Irish Famine on singular causes, such as its rapid population expansion, trade relations with Britain, or extensive reliance on potato-based subsistence agriculture (Bourke, 1959; Downey, 1996). Many of these claims are misguided, serving only to obscure the existence of internal variations in social-ecological structure within Ireland at this time, and the multiple causal pathways giving rise to differing levels of distress across regions.

This study seeks to extend the analytical scope of applied resilience ecology, by exploring the internal diversity of resilience in Ireland throughout this period. Through a cluster analysis of aggregate Irish data from the mid-nineteenth century, it attempts to quantify the determinants of regional-level risk exposure by grouping regions into distinct social-ecological regimes according to demography, geography, and social structure within Ireland’s 32 counties. This alternative methodology seeks to combine political-economic indicators relevant to the entitlements approach, along with other indicators of social-ecological structure which reveal the channels through which lower-level regional units may become exposed to heightened ecological risk. In this way, an analysis of the macro-level political economy of food security may be combined with a more nuanced model of social-ecological structure, in order to augment the shortcomings of a strictly political-economic, or food supply model alone.

2. The macro-context of nineteenth century Ireland

Existing accounts of the social, agrarian, and ecological structure of Ireland throughout the Great Famine have often resorted to macro-models and typologies, which attempt to impose conceptual uniformity on the Island as a whole. Kevin Whelan’s four-fold typology of eighteenth century ‘regional archetypes’ centered on dominant productive activities, is prominent amongst these (Ó’ Gráda, 1994: 35; Whelan, 1995, 2000). Whelan’s model identifies a *pastoral* archetype running from Leinster in the east, to inner Connaught in the west, driven by export price fluctuations; a *tillage* archetype of mixed farming extending across the south-eastern Anglo-Norman coastlands from Cork to Wexford, and northwards from Wicklow to Dundalk; and a *proto-industrialisation* archetype, spurred by favourable technology, infrastructure, and competitive innovation, centred on key northern production zones of the Ulster linen trade (Whelan, 2000). Whelan’s fourth archetype of *small farming*, concentrated in a western crescent running from Cork to North Donegal, is of greatest interest in light of its problematic influence on Irish historical geography throughout the twentieth century. The unique ecology of this marginal ‘peasant fringe’ has long featured as a recurrent theme in both academic and popular discourse (MacNeill, 1921). Historically, this zone of

settlement has been associated with poor quality marginal lands, high rates of poverty, and the extensive presence of the rundale system (Evans, 1957).

Rundale was a system of communal land management practiced extensively throughout the west of Ireland during the eighteenth and nineteenth century, where farms were held in partnership, and individual families were allocated shares, subject to periodic redistribution by a deputed headman, or village council (Bell and Watson, 2006; McCourt, 1955a; Slater, 1988). The lands of the infield, adjacent to the village buildings or ‘clachán’ were kept under continuous tillage, whilst livestock were herded for summer grazing on surrounding lands known as the ‘outfield’ (O’ Sullivan and Downey, 2008). The balance of tillage and livestock offered by this infield-outfield rotation, enabled a system of mixed farming to thrive amongst individuals with otherwise limited resources (Uhlir, 1961; McCourt, 1955b). In the winter, livestock were permitted free reign over the infield lands to graze crop stubble, providing a crucial source of fertiliser for the subsequent growing season. The pooling of labour within rundale also allowed for extensive land reclamation, enabling the system to sustain rapid demographic growth during the eighteenth century (Slater and Flaherty, 2009). An erroneous over-generalisation of this western *small farm* archetype to the island as a whole, thus formed the basis of a monolithic ‘peasant subsistence’ model of pre-famine Irish agriculture, which glossed over the internal complexities of settlement distribution, social stratification, and economic activity (Doherty, 2000).

There is much evidence to warrant a closer inspection of the characteristics of this Western *small farm* archetype. According to the work of Desmond McCourt (1971), the existence of a peripheral *small farm*, or distinctively western archetype is substantiated by first edition ordnance survey maps of the 1840’s, which reveal extensive *clachán* settlement – the characteristic village clusters of rundale – concentrated within the areas bounded by Whelan’s small farm zone (see figure 1 below for a tabulation of common holding rates within counties). For County Mayo, Desmond McCabe (1991) estimated up to 831,000 acres, or 63% of the total area of County Mayo, was held in rundale in the 1840’s. Classic pronouncements on Ireland’s unique demographic regime, such as those of K.H. Connell (1950b, 1962), have also identified the critical roles of wasteland reclamation, and the ability of the potato both to prosper in poorer quality soils, and to yield a diet of sufficient calorific adequacy on small acreages, as key factors facilitating early marriage, high fertility, and high population density under rundale.

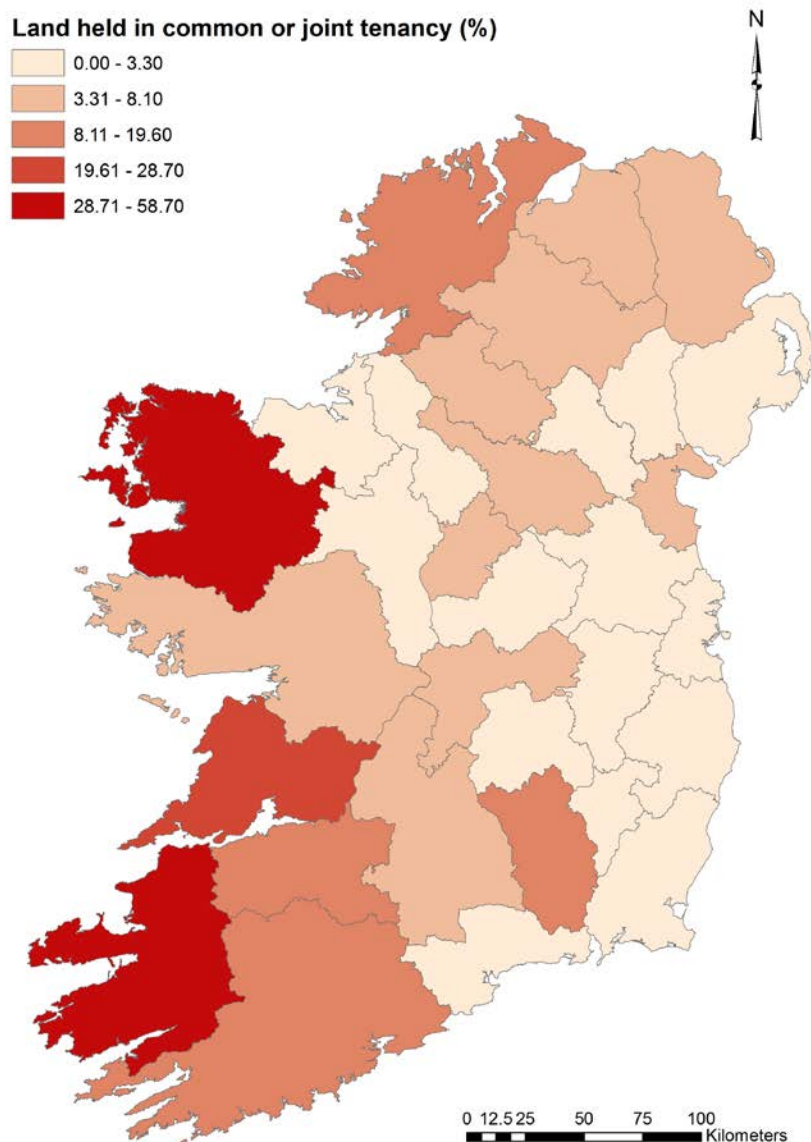


Figure 1. Lands held in common or joint tenancy (rundale) (Devon Commission 1845)

The rundale system was thus especially ecologically precarious; it suffered from over-population and monoculture dependence, whilst being simultaneously tied into a rent relationship under British colonialism, as was the case with all Irish tenant farmers at this time (Slater and McDonough, 2005). This relationship required the continuous sale of agricultural surplus in order to meet rental obligations to local landlords. As agricultural produce was sold beyond the boundaries of these settlements to be consumed in urban centres far from their sites of production, they suffered declines in fertility through loss of repatriated nutrients, and came to subsist on a narrower range of crops as their grains were increasingly consigned to the market (Flaherty, 2013; Hooper, 1922). There is little doubt that this western crescent was subject to the worst effects of the famine between the years 1845 and 1852, as Kinealy's poor-law union level analysis of variability in the uptake of soup rations throughout the famine years has identified a concentration of high distress in the western counties of Galway, Mayo, Clare, Kerry and Limerick (2006: 369).

Tabulation and mapping of agricultural census data of 1851 completed by the National Centre for Geocomputation (2010), further underscores the presence and continuities of such regional distinctions. As may be observed in figures 2.1-2.4, profound regional distinctions are evident in crop distribution patterns. Production of potato (figure 2.1) follows a western crescent with some southern and north-eastern pockets, whilst that of wheat (figure 2.2) is centred along an Anglo-Norman tract extending from the south-west to south east coasts, whilst flax cultivation (figure 2.3) is centered on the protoindustrial spinning and weaving districts of the north. Valuation (figure 2.4) displays a distinct westerly trend, with concentrically decreasing levels from east-west. Although a number of profound correlations are evident, most notably a concentration of potato cultivation and lower land valuation across the western fringe - in turn corresponding to the distribution of rundale as noted in figure 1 – some reservations are warranted.

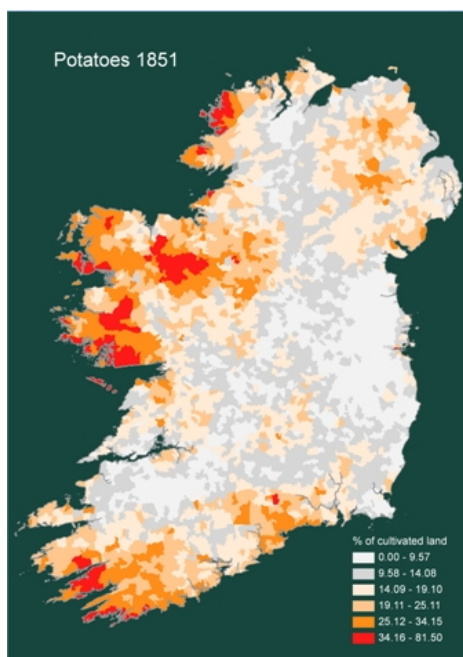


Figure 2.1. Potato as % cultivated land (National Centre for Geocomputation, 2010)

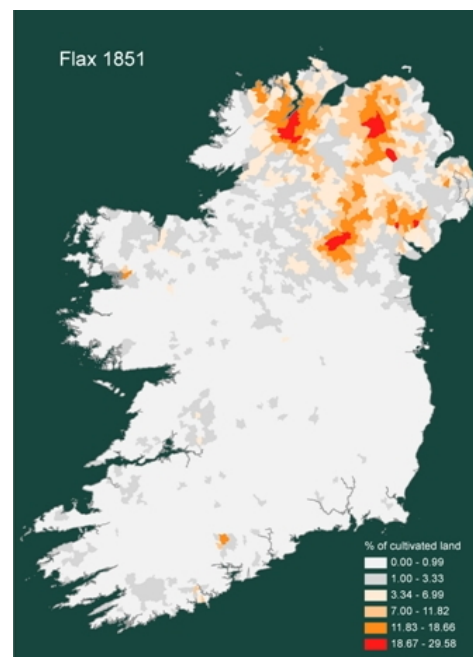


Figure 2.3. Flax as % cultivated land (National Centre for Geocomputation, 2010)

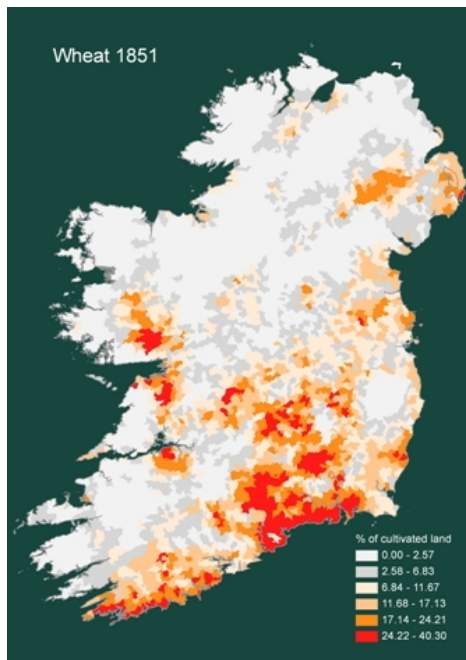


Figure 2.2. Wheat as % cultivated land (National Centre for Geocomputation, 2010)

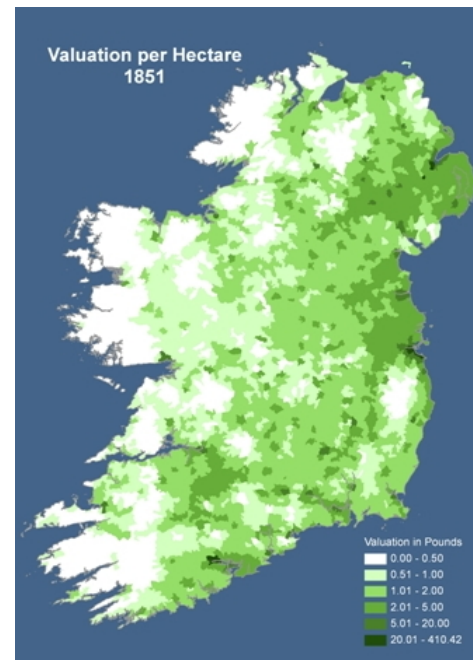


Figure 2.4. Valuation per hectare (National Centre for Geocomputation, 2010)

On the extent of domestic industry for example, Almquist (1977) and Gray (2005) have pointed out that spatial typologies alone are not representative of its true significance throughout this period, as large proportions of rural households along the western Atlantic seaboard engaged in small-scale spinning as a key source of supplementary income (Gray notes over 50% of all occupied women in Donegal, Galway and Mayo were spinners, 2005: 52). Furthermore, patterns of high land fragmentation and early female nuptiality thought characteristic of the ‘small farm zone’ of the west of Ireland, prevailed across much of Ireland throughout the early nineteenth century, resulting in 45% of all enumerated holdings across Ireland falling below five acres by 1841 (Connell, 1950b: 284). This presents both a conceptual and typological problem; given that similar social processes such as protoindustrialisation and land subdivision operated across regional boundaries, univariate spatial typologies alone are arguably incapable of fully revealing the complex dynamics underpinning the formation of regional inequalities in poverty, and ecological risk exposure.

In order to make sense of famine-era variations in resilience and risk exposure, given that reliance on geographical patterning only takes us so far, what is instead required is a typological approach which permits closer examination of the presence of regional distinctions and consistencies at a greater level of abstraction, using variables which move beyond productive activity alone. Resilience ecology suggests working from local contexts, in order to identify specific sets of conditions which may generate uneven patterns of risk exposure. Such an approach requires working with data in a manner different from cross sectional modelling; what we are seeking to uncover is not the additive effect of variables across complete sets of data, but rather the ways in which variables ‘group together’ in different ways across cases, giving rise to differing levels of resilience. Cluster analysis therefore offers a way to develop a comparative typology capable of addressing this question of multilevel systemic complexity.

3. Data and methods

The following sections present the results of an exploratory *k*-means cluster analysis, conducted with the intention of extracting a latent typology of *cases* from a set of county-level variables (N=32) measuring a range of social, geographic, and demographic attributes of mid nineteenth-century Ireland. These county units incorporate all of the land mass of Ireland at this time. In context of the preceding discussions, and on the basis of prior empirical research, particularly that of Eric Almquist (1977), who has subjected many of the following variables to regression modelling with productive results, the following variables were selected (see table 1). These variables represent a parsimonious range of attributes relevant to the social-ecological profile of Ireland at this time, through which regimes of ecological risk may be discerned.

The inclusion of demographic variables in the form of *land-labour ratio* and *females 26-35 married/widowed* is substantiated by existing literature on Ireland as discussed above, and within broader works in human ecology (see table 1 for variable descriptions, and theoretical justifications). Age at marriage is largely a function of local conditions such as access to land for new settlement, inheritance patterns, family structures, and local cultural norms. This variable allows us to distinguish areas of later and earlier marriage trends, where union may be delayed owing to difficulties in securing inheritance, in the absence of subdivision or land reclamation. Therefore, areas with higher nuptiality rates, extensive subdivision, and limited outmigration should record higher percentages on this variable. Such population-specific variables often feature as predictors of stress in models of resource consumption (Axinn and Ghimire 2011).

The inclusion of variables beyond these ‘Malthusian’ parameters alone is justified in the context of this study, as a counterpoint to simple population determinism; hence the inclusion of *land held in common or joint tenancy* as an index of the presence of particular institutional modes of land governance (the communal rundale system as discussed above). The role of wasteland as a determinant of settlement expansion is well established in existing work, and many have drawn attention to the inherent tendencies of collective leasing regimes such as rundale, particularly as they permit reclamation, and consequently, accommodation of new settlement members (Connell 1950b; Currie 1986; McCourt 1955a, 1971; Slater and Flaherty 2009). Elinor Ostrom’s work (1990) has also shown how systems of common pool resource governance are ideally suited to intense resource exploitation, where large territories are required to make production viable, and where large groups are needed to perform the common labour necessary to bring marginal lands under cultivation. These reclamation activities were particularly prevalent across rundale-dense areas. Summary statistics, correlations, and a scatterplot matrix are provided below in tables 2 & 3, and figure 3.

Table 1. Description of input variables

Variable	Unit	Source	Theoretical/empirical justification
Land-labour ratio	Statute acres per individual	Census of Ireland, 1841	Hypothesised by Chayanov as key determinant of household labour strategies. Elevated/diminished ratios are associated with probability of uptake in subsidiary domestic industry / labour intensive crop cultivation (O' Neill 1984)
Poor law valuation	£(pounds) per individual	Almquist (1977)	Reliable index of poverty – lower valuations are associated with lower potential land productivity
Females 26-35 married or widowed	% all females	Vaughan and Fitzpatrick (1978)	Cited as key independent variable in land-use outcome explanation. Often-hypothesised component of pre-famine Irish demographic expansion (Connell 1950a), closely related to subdivision, and viability of potato
Holdings 1-5 acres	% of all holdings	Almquist (1977)	Rundale systems are characterised by fragmentation of holdings through subdivision
Waste (course pasture) below 800ft above sea level	% of all county wasteland	Devon Commission (1845)	Wasteland / course pasture encroachment cited as characteristic of rapidly expanding rundale settlements. Wasteland availability conducive to resilience of communal systems through spatial expansion
Land held in common or joint tenancy	% of all county land	Devon Commission (1845)	Indicator of potential presence of the rundale system of communal tenancy

Table 2. Input variable summary statistics (N=32)

Variable	Unit	Mean	SD	Min	Max
Land-labour ratio	Statute acres per individual	2.68	0.81	0.61	4.04
Poor law valuation	£ (pounds) per individual	1.56	0.58	0.66	3.03
Females 26-35 married or widowed	% all females	70.35	6.03	59.49	81.85
Holdings 1-5 acres	% of all holdings	42.33	11.12	27.9	72.6
Waste (course pasture) below 800ft above sea level	% of all county wasteland	57.9	26.00	0	98.46
Land held in common or joint tenancy (logged for cluster model and correlations)	% of all land	8.91	12.42	0	58.7

Table 3. Correlation matrix (N=32)

	Land-Labour	Poor law	Married	1-5 acre	Waste	Common
Land-labour	1.000					
Poor law	-0.1308	1.000				
Married	0.1466	-0.6568***	1.000			
1-5 acre	-0.0346	-0.5368**	0.6351***	1.000		
Waste	0.5134**	-0.3276	0.4500**	0.3276	1.000	
Common	0.1989	-0.4648**	0.4393*	0.0842	0.1038	1.000

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

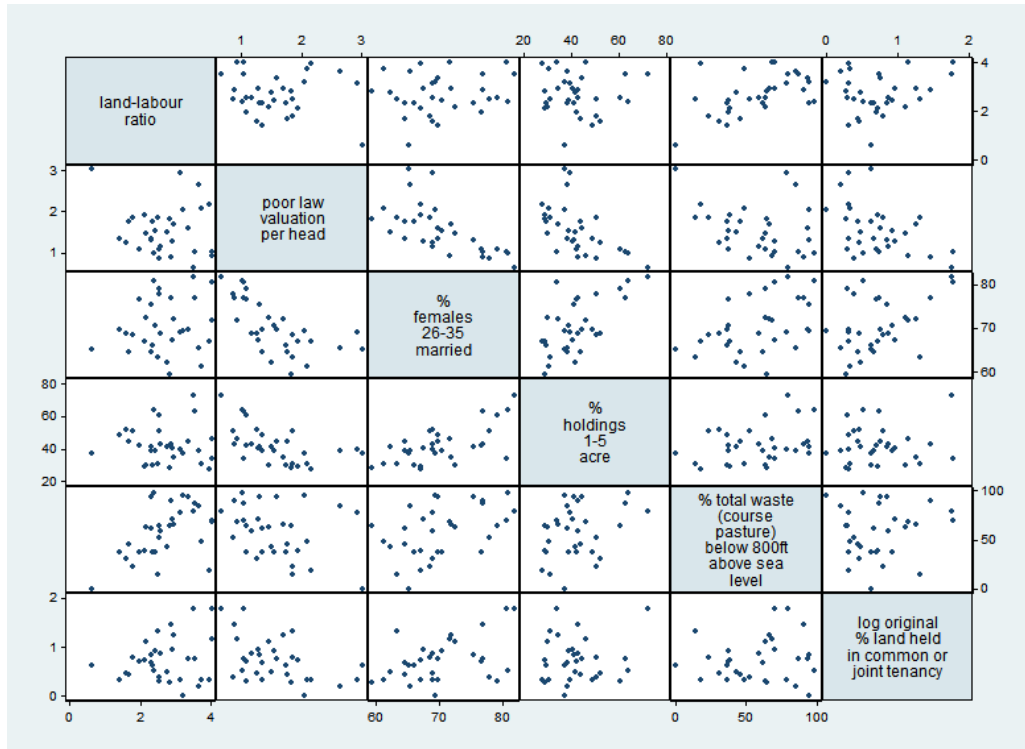


Figure 3. Input variable scatterplot matrix

As may be observed in the above tables and figures, and as previously detailed by Almquist's cross-sectional models (1977), the chosen input variables exhibit suitably broad ranges (table 2, min & max). Furthermore, a number of significant correlations are evident within table 3 and figure 3. Consistent with existing theory, the key demographic variable of *females 26-35 married* demonstrates strong, significant correlations with others including *holdings 1-5 acres* ($r = 0.6351$, $p \leq 0.05$), *waste* ($r = 0.45$, $p \leq 0.05$) and *common* ($r = 0.4393$, $p \leq 0.05$). Thus we observe strong positive associations between the demographic regime of high early female nuptiality, classical predictors of population growth (availability of wasteland), and a number of consequent effects of demographic expansion, such as fragmentation of holdings, and the presence of common holding. Of note also are strong, negative associations between land valuation (*poor law valuation*), *females 26-35 married* ($r = -0.6568$, $p \leq 0.05$), *holdings 1-5 acres* ($r = -0.5368$, $p \leq 0.05$) and *land held in common* ($r = -0.4648$, $p \leq 0.05$). Such associations point toward a diminished probability of early marriage, land fragmentation and common holding within more affluent districts.

As stated above, the purpose of exploratory cluster analysis is to extract latent typologies of *cases*. For *k*-means optimization techniques as utilised below, *k* denotes the number of groups required by the clustering procedure, and is a user-defined input parameter (unlike hierarchical procedures which progressively match cases on the basis of similarity/distance measures). *K-means* clustering adopts trace (W) minimization as its optimization criteria (see Everitt et al 2011: 126). Although a number of formal procedures exist for the estimation of potential group numbers for optimisation clustering methods, such as the Calinski and Harabasz pseudo *F*-statistic (Rabe-Hesketh and Everitt 2004: 276), and the Duda and Hart index (Everitt et al 2011: 127), Landau and Everitt (2004) suggest that many of these techniques are inherently ad-hoc. Mardia, Kent and Bibby's rule of thumb [$g \sim (n/2)^{-5}$], for example, yields a preliminary value of 4, where *n* is the number of counties – in this case, 32 (1979: 365). On the basis of

existing theory and research, and in light of the small available sample size, an input constraint of four groups was specified. This estimated value of k agrees with previous classifications of Ireland, which have tended to emphasise four distinct socio-economic zones (Ó' Gráda 1994, Whelan 2000, National Centre for Geocomputation 2010).

All variables were z-score standardised (to mean 0, standard deviation 1) prior to application of the clustering algorithm, consistent with Everitt et al's recommendations, given that optimization methods are inherently scale dependent (Everitt et al 2011: 115). A log transformation was also applied to the variable *common* prior to clustering, in order to correct a profound positive skew, with the addition of a constant of 1, due to the presence of '0' values in the original dataset. Correlations from table 3, figure 3, and the boxplot of figure 5 report values for the *transformed* variable, whilst other output (tables 2 and 4) reports values from the *untransformed* variable for ease of interpretation.

4. Results and discussion

The benefits of employing a k -means method in the context of this research, are that such techniques '...seek to minimize the variability within clusters and maximise variability between clusters' (Landau and Everitt 2004: 312), yielding a set of groups optimally distinct from each other, yet retaining a significant degree of internal homogeneity (Byrne 1998). This process is theoretically consistent with the concept of *regimes* as informed by resilience ecology, whereby each cluster group may be interpreted as a distinct, internally consistent social-ecological regime. Complete output generated from the clustering procedure is provided as an appendix, although this output is less intuitively interpretable owing to necessary standardisations employed prior to running the clustering algorithm. The reader may discern cluster centroids more intuitively through the following tables (3 and 4), which tabulate final cluster solution group members (table 3), and input variable summary statistics according to derived cluster group membership (table 4).

Table 3. Cluster solution group members

Group 1	Group 2	Group 3	Group 4
Antrim	Armagh	Carlow	Clare
Down	Cavan	Kildare	Donegal
Dublin	Cork	Meath	Galway
Kilkenny	Fermanagh	Queen's	Kerry
Louth	King's	Westmeath	Mayo
Tipperary	Leitrim	Wexford	
Waterford	Limerick	Wicklow	
	Londonderry		
	Longford		
	Monaghan		
	Roscommon		
	Sligo		
	Tyrone		

Table 4. Input variable summary statistics by cluster group membership									
Variable	Unit	Group 1		Group 2		Group 3		Group 4	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD
Land-labour ratio	Acreage per head of population	1.93	0.67	2.40	0.54	3.33	0.47	3.60	0.47
Poor law valuation	£ (pounds) per head	1.96	0.49	1.27	0.23	2.17	0.48	0.91	0.15
Females 26-35 married	% all females	66.47	2.44	72.61	4.94	64.84	3.89	77.62	3.95
Holdings 1-5 acres	% all holdings	37.31	8.14	45.43	9.69	34.90	5.62	51.72	15.78
Waste (course pasture) below 800ft above sea level	% total county waste	28.13	16.34	63.78	21.81	61.70	26.74	78.99	9.67
Land held in common or joint tenancy	% all land	6.44	6.08	5.39	21.81	1	0.64	32.66	24.99

On the basis of these results, a number of distinct social-ecological regimes may be discerned; this typology performs well in isolating the characteristics of areas prone to ecological stress, by identifying conditions within regions which (as will be examined below), exacerbated the experience of distress during the peak famine months. In light of the summary statistics presented in table 4, a distinct regime may be observed, described by the territories of **Group 4** (Clare, Donegal, Galway, Kerry and Mayo); the consistency of this group is defined by its high *land-labour ratio* (3.6), low *poor law valuation* (£0.91), high proportions of *females 26-35 married* (77.62%), high fragmentation of holdings *1-5 acres* (51.72% of all holdings), high availability of *wasteland* (78.99%), and greater prevalence of *common landholding* (32.66%). This may be contrasted with the regime described by **Group 1**, characterised by significantly higher *valuation* (£1.96), lower fragmentation of holdings *1-5 acres* (37.31%), limited *wasteland* (28.13%), and comparative absence of *common landholding* (6.44%). The magnitude of these between-group differences may be observed by examining boxplots generated by cluster group membership for variables *female 26-35 married* (figure 4) and *land held in common or joint tenancy* (figure 5).

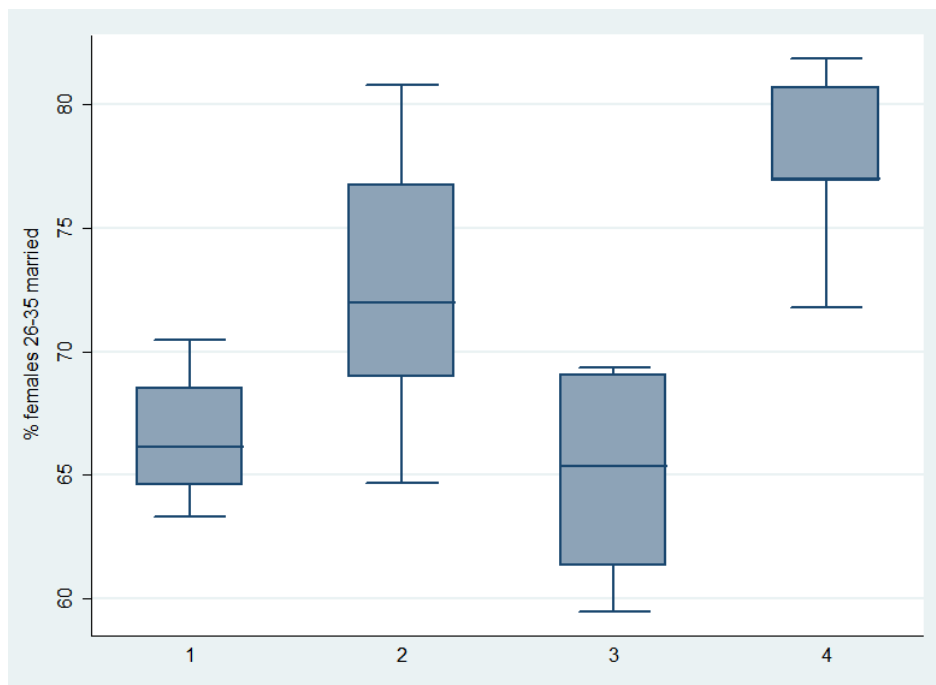


Figure 4. Boxplot (% females 26-35 married or widowed) by cluster group membership

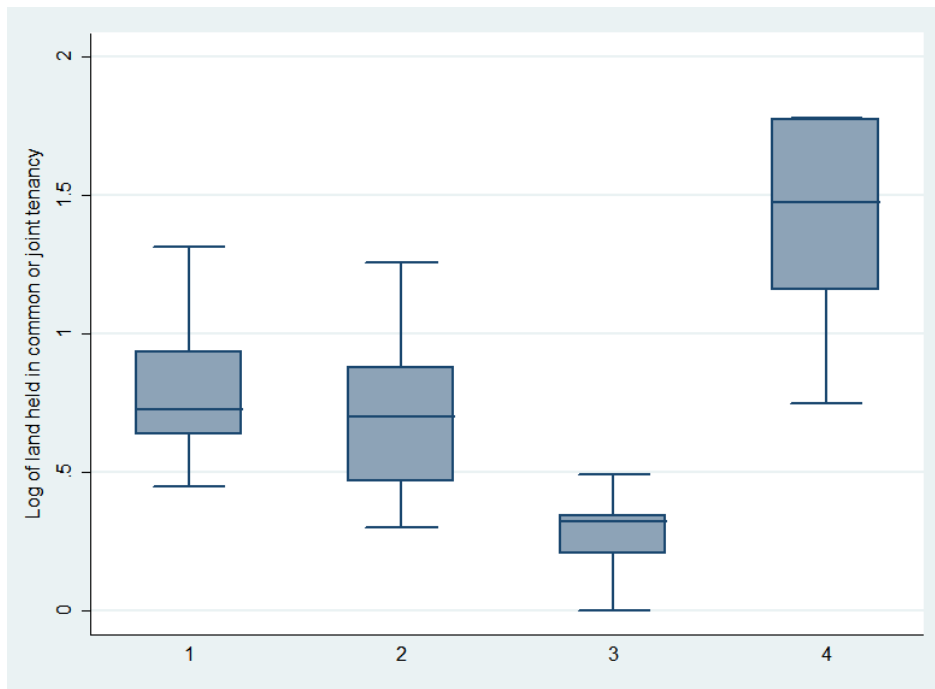


Figure 5. Boxplot (log % land held in common or joint tenancy) by cluster group membership

A further advantage of this approach is that it allows us to move beyond stability-based metrics such as aggregate population growth, which are incapable of adequately grasping potential heterogeneity in sub-system variants; ‘...stability concepts can, with the exception of ‘persistence’, not be applied to entire systems but only to specific state variables characterizing these systems’ (Grimm and Calabrese 2011: 5). Adopting a definition of resilience centered on the capacity of a system to ‘...retain essentially the same function, structure, identity, and feedbacks’ (Walker 2004 cited in Grimm and Calabrese 2011: 8), it is clear how the regional characteristics described by the above typology conferred varying degrees of risk exposure. In the case of group four, the comparatively poorer quality of land, and its lower potential productivity (*poor law valuation*), coupled with high rates of fragmentation (*Holdings 1-5 acres*), led to greater stress on the means of production as communities were forced to subsist on plots of diminishing size. This condition was assisted both by the presence of available wasteland for colonisation (*Waste*), spurred by a demographic regime of high early nuptiality (*Females 26-35 married*). These critical dynamics are often cited in the literature on Ireland as key pre-famine stressors, although their varying prevalence across Ireland at this time has not been adequately substantiated (Connell 1950a, 1950c).

In the rundale-dense counties of group four, the capacities of common holding regimes to adapt to conditions of ecological marginality has often been emphasised (Whelan 1995, 1999). Under pre-famine landlordism, the rundale system was ideally suited for rent-based profit maximisation, given its tendencies toward exponential growth. With abundant wasteland to accommodate new members, and the prolific potato crop which yielded sufficient output to feed families on small acreages, landlords permitted subdivision on their estates as a means of maximising rent returns throughout the buoyant grain economy of the Napoleonic wars (Slater and McDonough 2005). As the post-war grain economy contracted, and prices of livestock and wool began to increase, the imperatives of landlordism quickly shifted toward consolidation: the clearing of estates, enclosing of commons, and letting of lands to large graziers. As a result,

the regions of group four experienced particular resilience loss, as their capacity to adapt to change became rapidly diminished in the pre-famine era (Slater and Flaherty 2009). As eviction, clearance, and excess mortality took hold into the late 1840's, the ability of settlements within this group to maintain their structure and identity was critically compromised.

Clearly this narrative risks glossing over local heterogeneity and caution must be exercised in mapping any such model onto particular cases. When comparing group four with group three, the qualitative differences amongst regimes are most clearly underscored. Many of the counties of group three occupy Whelan's classic 'tillage zone', where grain productivity was typically at its highest. Such areas benefitted from productivity upscaling under land consolidation, and from wartime grain price upsurges, as reflected in this cluster's high valuation (*poor law valuation*), and low levels of fragmentation (*Holdings 1-5 acres*). Common holding (*Land held in common*) was all but absent, and nuptiality was lower (*Females 26-35 married*), leaving this cluster beyond the boundaries of the classic demo-economic model of expanded fertility (Clarkson 1981; Connell 1950a; Gray 2005), typically brought to bear on the island as whole.

Resilience and distress: the uneven impact of famine

The explanatory power of these qualitative regime differences is further illustrated by a decomposition of distress estimates across cluster group membership (figure 6). The below data on ration uptake are drawn from six successive reports of May 8th, June 5th, July 3rd, July 31st, August 28th and September 11th 1847, and the largest number of rations issued on a single date across all reporting periods was selected for inclusion. This current measure differs slightly from that of Kinealy (2006), as it is first calculated as the rate of rations issued per head of population before standardization (again, to mean 0, standard deviation 1). Figure 6 (below) shows how group four fared worst in terms of the uptake of gratuitous relief rations during the critical summer months of 1847, when the impact of famine was reaching its peak.

A one-way ANOVA with post-hoc group comparison quantifies the magnitude of these between-group differences more precisely, and table 5 (below) shows how membership of group four was associated with significantly greater ration uptake. The extent of ration uptake within group four contrasts markedly with that of groups two and three, as may also be observed in figure 6. Although it is impossible to include additional covariates and controls owing to the small sample size of this dataset, the difference recorded for group four, coupled with its significance in the model, suggests that it stands apart as a regime of particular hardship.

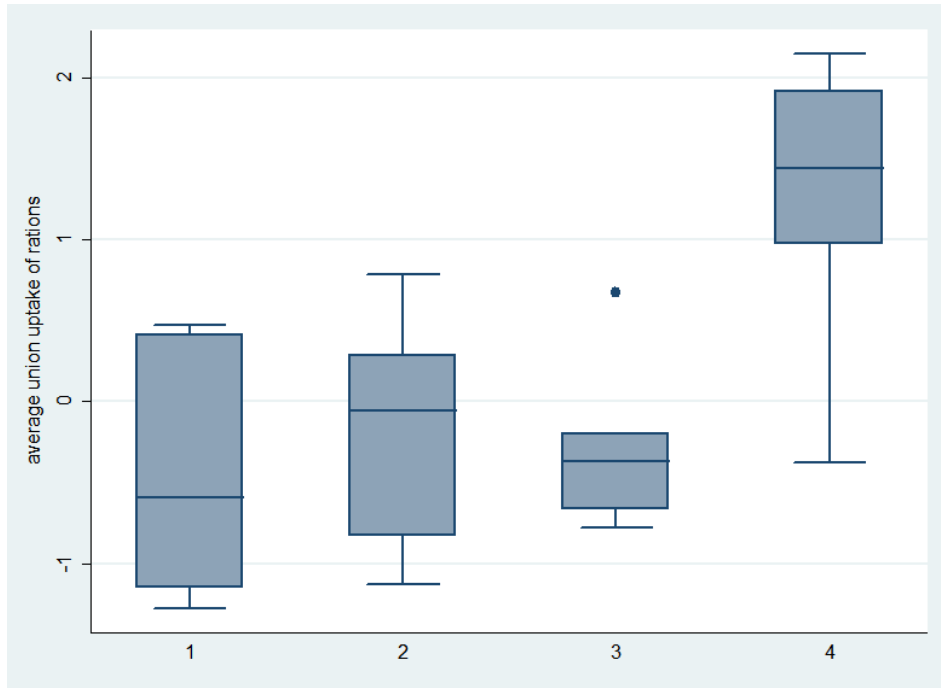


Figure 6. Uptake of relief rations by cluster group membership

Table 5. One-way ANOVA with post-hoc group comparisons (Dunnett)

	Mean difference	Standard error
Group 1 (reference)	-	-
Group 2	-.287	.331
Group 3	-.023	.302
Group 4	1.14***	.331
<i>F</i>	8.305***	
<i>N</i>	32	

*** $p < 0.001$

Data on ration uptake sourced from *Second Report of the Relief Commissioners, constituted under the act 10th Vic., cap. 7. 1847* [819] xvii, pp24-26; *Third Report of the Relief Commissioners, constituted under the act 10th Vic., cap. 7. 1847* [836] xvii, pp30-31; *Fourth Report of the Relief Commissioners, constituted under the act 10th Vic., cap. 7. 1847* [859] xvii, pp6-7; *Fifth, Sixth and Seventh Reports of the Relief Commissioners, constituted under the Act 10th Vic., cap. 7. 1847-48* [876] xxix, pp7-8; 8-9; 8-9

The subjective experience of distress between groups was also somewhat different. Writing on the county of Mayo (group four) in the winter of 1847, Poor Law Union inspector Richard Hamilton observed; ‘...I visited the village a month ago, and found the greatest destitution existing in it; but on going there again the day before, I was not a little astonished to find

nothing but the walls of the houses remaining, the inhabitants being scattered through the country seeking shelter where they could best find it' (Yager 1996: 30). Many landlords took advantage of famine conditions to enact estate-wide clearances of smallholders and rundale tenants, and estimates of the extent of famine-era evictions stand at between 200,000 and 250,000 individuals (Orser 2006b: 180). According to Vaughan, '...around 37,286 evictions may have occurred between 1846 and 1849 alone, with somewhere around 16,400 houses being levelled' (ibid).

The comparative resilience of group two was doubtless augmented by the presence of proto-industrialization in the Northern counties of Fermanagh, Cavan, Armagh, and Londonderry, and their close integration with the core 'linen triangle' of Dungannon – Belfast – Armagh (see the distribution of flax in figure 2.3). In such cases, buoyant linen markets offered a subsidiary source of income which imbued such regions with an inherent market-derived flexibility (Gray 2005). This could also have an opposing effect however. Rev. Nixon of North West Donegal (group four), upon assuming title to the Copeland estate in 1844, promptly annexed extensive tracts of mountain land in order to graze a prolific breed of sheep in response to rising wool prices, disrupting long-held grazing rights of the tenantry who were accustomed to grazing their livestock on the mountain commonage, as an essential component of their seasonal rotation (Mac Aoidh 1990).

Crucially, the differing between-group nature of the 'indirect entitlement' of subsidiary industry is more intelligible in context of the conditions revealed in the above cluster analysis. In the case of group two, elevations in early nuptiality were absorbed by the division of household labour in domestic spinning, and the importance of these subsidiary domestic industries as a means of absorbing excess labour has been well substantiated by existing scholarship (Almquist 1977; Gray 2005). Thus in group two, elevated nuptiality and land fragmentation were offset by the proximity of some counties to buoyant linen markets in the North. In other groups, high nuptiality, combined with high fragmentation, and the comparatively smaller scale of domestic spinning, meant that such areas were materially poorer due to their sustained dependence on direct subsistence, and other sources of farm-related income.

Comparative disadvantage was also compounded within group four, due to the absence of capital investment in agriculture, unlike in the northern counties where the provisions of 'Ulster custom' ensured that tenants retained the right to uninterrupted sale of their lease, allowing them to benefit from fixed agricultural improvements (Dowling 1999). Similar provisions were not in place beyond the north. Due to the communal nature of production under rundale, and the balance of legal property rights in favor of agent and landlord throughout all regions, investments in permanent improvements made little economic sense to the southern tenantry, who stood to lose the value of their labour should their lands be sold, or their plots redistributed. As a result, the counties of group four suffered from multiple constraints, owing to the underdevelopment of agricultural capital and technology, high settlement density, and the insecurity of seasonal productivity on marginal lands. By the time blight arrived in 1845, the conditions of crisis were firmly entrenched; it required merely a small change in ecological fortune to destabilize the system to the point of collapse (see also Fisk and Kerhevre 2006; Kinzig et al 2006).

5. Conclusion: theoretical and methodological implications

The preceding exercise has captured substantial internal diversities not typically revealed through the use of aggregate models, and the regimes identified above further underscore the problematic nature of Malthusian models of food security. Although nationwide demographic expansion doubtless fed into the precariousness of Irish society in the pre-famine era, this was mediated profoundly through local variations in social-ecological resilience, as captured by the above typology. Such diversity renders any account of food security based on national-level causes problematic, insofar as the ability of regions to successfully cope with ecological stress depended on their underlying structural characteristics.

The nature of resource entitlement channels, or the manner in which individuals alternately engaged with markets or in subsistence production to secure their livelihoods, was also not uniform across the country. Although many have emphasised the capitalistic nature of Irish society at this time (Hazelkorn 1981, 1983; Meiksins Wood 2002), it is clear from the preceding analysis that there existed remarkable continuities in non-capitalistic land tenure or ‘rundale’, across vast swathes of the Irish countryside during the mid nineteenth century. This is a crucial point, as it introduces the possibility for substantial variation in the ways in which individuals engaged with capitalistic markets for the sale of their surplus produce, whilst continuing to organise agricultural production in a fundamentally non-capitalistic manner. With regard to entitlement-based models of food security, it therefore becomes decidedly difficult to characterise the structure of Ireland’s indirect entitlement channels, given the variety of ways in which market mediation is likely to have penetrated agricultural production at settlement level (Devereux 2001).

Although this exercise bears numerous theoretical implications, they must be advanced with a measure of caution, as the preceding exercise has relied upon data drawn from ecological units (i.e. counties). Despite the limited capacity of ‘aggregate approaches’ to fully account for relationships at lower levels of aggregation, the explanatory power of the social-ecological regimes identified above is no less diminished *a priori* by the utilisation of spatial units by the analyst, with whom blame must also reside when the explanatory limitations of ecological units are breached, and projected downward onto individuals. It is therefore critical not to over-generalise such associations, or to assume that the characteristics of individual settlements within the above regimes will necessarily display similar associations. Given a comparative lack of data at lower levels of aggregation, such limitations are unfortunately unavoidable.

By serving as an orienting device, this exercise confirms something of the exceptional nature of the peripheral western regions of nineteenth century Ireland, quantifies these regional differences, and offers a basis for subsequent local inquiry. From the preceding results, we observe merely a *potential* differential distribution of social-ecological resilience across the territory of Ireland, by noting areas subject to greater probabilities of ecological stress. This tells us little of the dynamics of *localised* social-ecological systems, or individual settlements however. Herein lies the precise appeal of a resilience approach; its conceptual approach invites qualitative investigation at lower levels of aggregation, by working from the characteristics of cases themselves, rather than deriving system dynamics from a-priori variables alone. This is a fundamentally different approach to that of cross-sectional modeling, which assumes a constant, additive effect of variables across all cases (Byrne 1998, 2005). This exercise has offered a modest starting point from which to begin assessing this uneven nature of famine, as well as a general methodological template which might be adopted in other cases, as a ‘first pass’ means of overcoming variable-driven explanations of food insecurity.

Appendix

Cluster analysis output

Initial Cluster Centers				
	Cluster			
	1	2	3	4
zscore: population density	-2.55204	-.19206	1.18460	1.01252
zscore: poor law valuation per head	2.52063	-1.20268	1.8517	-1.54584
zscore: % females 26-35 married	-.86642	1.24137	-.86642	1.88992
Zscore: % total waste (course pasture) below 800ft above sea level	-2.22270	-.22563	1.04174	.84972
Zscore: % holdings 1-5 acres	-.40549	.76592	-.31538	2.74829
Zscore: log original % land held in common or joint tenancy	-.23244	-.76598	-1.20503	2.34405

Iteration History				
	Change in cluster centers			
Iteration	1	2	3	4
1	2.164	1.523	1.501	1.828
2	.756	.213	.340	.616
3	.205	.174	.000	.492
4	.000	.175	.000	.451
5	.000	.000	.000	.000

Final Cluster Centers				
	Cluster			
	1	2	3	4
zscore: population density	-.92779	-.36225	.79303	1.13052
zscore: poor law valuation per head	.68962	-.50447	1.04749	-1.12032
zscore: % females 26-35 married	-.63480	.38079	-.93591	1.20894
Zscore: % total waste (course pasture) below 800ft above sea level	-1.14187	.22637	.14196	.81131
Zscore: % holdings 1-5 acres	-.45698	.27379	-.65006	.83800
Zscore: log original % land held in common or joint tenancy	.10568	-.06584	-1.03279	1.46913

Number of cases in each cluster	
Cluster	Cases
1	7
2	13
3	7
4	5
Valid	32
Missing	0

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